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Background for Joint Systems Aspects af AIR 6000

Rod Staker and Terry Moon

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Joint Systems Branch
Electronics and Surveillance Research Laboratory

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ABSTRACT

This document provides background information that will be used as a basis for studies undertaken as part of the Joint Systems Aspects of AIR 6000 task. It discusses some of the issues surrounding the AIR 6000 project and describes the context for future Joint Systems Branch studies in support of the project.

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Background for Joint Systems Aspects of AIR 6000

Executive Summary

The purpose of this document is to provide background information to be used as a basis for studies undertaken as part of the Joint Systems Aspects of AIR 6000 task. It is a distillation of a lengthier framework document, currently in preparation, which discusses in greater depth the matters mentioned here.

This document first discusses some of the issues that surround the AIR 6000 project. These have been collected from various sources, including the "Control of the Air Conference" organised by the Australian Defence Studies Centre and held in Canberra in November 1999.

The context for future studies into the joint systems aspects of the project is discussed and established. This is based on the underlying tenets of Australia's strategic outlook that are likely to be enduring over the timeframe of interest.

Due consideration of the relevant joint systems aspects of AIR 6000 will be essential if Australia is to acquire an affordable and effective new aerospace combat capability.

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He has worked on a number of major projects and studies including MODIR, Nulka, WASS, AIR 87, the Land Surveillance DFCOP and JP 129. Currently Terry is Head of Systems of Systems in Joint Systems Branch where the focii of his work are Project AIR 6000 and the C4ISREW study.

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1. Introduction

Project Air 6000 was established in the middle of 1999 with the task of providing the ADF with a new aerospace capability to follow on from that which is currently represented by the F/A-18 Hornet and F-111 aircraft.

The project will examine the broad, holistic, picture of air dominance and strike. This will necessarily include the interactions between air, land, and sea based assets. Command and control systems, intelligence, surveillance and reconnaissance, support requirements, and interoperability both within the ADF and with potential coalition partners will also be examined in detail. Therefore, there will be significant Joint Systems aspects to the project. Consequently, a research task has been established within the Joint Systems Branch of DSTO to undertake research work relating to these. The task has been entitled "Joint Systems Aspects of AIR6000" (AIR 00/018).

The purpose of this document is to provide background information to be used as a basis for studies performed under the task. It is a distillation of a lengthier framework document, which is currently in preparation, and which discusses some of the matters mentioned here in greater depth.

The paper first details some of the issues that surround the AIR 6000 project. These have been collected from various sources, including the "Control of the Air Conference", held in November 1999 in Canberra, and arranged by the Australian Defence Studies Centre.

It then describes the context that will be used for future studies into the joint systems aspects of the project. This is based around a "strategic outlook" which, it can be assumed, will not change significantly over the timeframe of interest.

2. Issues

Complex issues confront Australia in updating its aerospace combat capability. With the now enormous costs of weapon systems, it is necessary to abandon a traditional "replacement" philosophy to avoid block obsolescence resulting in substantial defence budget shortfalls. The effect of block obsolescence is exacerbated by a generally declining real rate of expenditure on defence. A relatively even rate of expenditure for systems acquisition is required in order to keep the impact of these on national finances manageable. The wide availability of technology means that sophisticated technologies are increasingly becoming available to potential adversaries. Australia's traditional alliances with countries such as the US, UK and New Zealand are becoming less relevant. There is a need to be able to undertake military operations at an affordable price. A number of dilemmas will need to be faced in achieving this.

It is an era of uncertainty. The disintegration of the Soviet Union and the Asian regional economic crisis were largely unexpected. These events teach us that a flexible approach must be adopted in developing a future force. In addition, considerable uncertainty exists in Australia's own region. Circumstances can change abruptly. The turmoil occurring in East Timor is a recent example. As a consequence, there has been increased attention focussed on defence issues. Australia faces a credibility gap between its declared strategic policy and its current capabilities. It has a historically low defence budget to meet its significant strategic posture.

An open and frank debate, without pre-existing convictions, is required on these matters. It may be necessary to consider innovative and unusual options. These could include space-based assets as well as air vehicles of various kinds. Space-based assets might, for example, be used for surveillance, intelligence collection and transmission of real-time targeting information to long-range weapons. In general, more focussed capabilities are required, rather than a broad spread of capabilities that may not be affordable. Expenditure must be focussed on those capabilities that are most likely to be pivotal in achieving the primary goals of the ADF.

Australian society is unlikely to favour increased spending on Defence. In fact, real cuts are likely to continue into the future. Historically, Australia has only been prepared to increase defence spending when directly involved in a conflict. It can therefore be questioned whether figures of the order of A$10bn for a replacement capability are justifiable and credible, given a current total Australian annual defence budget of approximately A$10bn.

Some other nations in the region are much more willing to devote substantial increases to defence spending. For example, India has just recently announced a 28% increase in defence spending to US$13.5bn per annum. Consequently, Australia's defence budget is likely to be significantly smaller relative to those of its neighbours by 2020. Ways in which the impact of this can be minimised need to be examined. In addition to having access to advanced weapons, by that date, the competency of their armed forces to employ them could be comparable to that of Australia's own force. Therefore, Australia will need to seek other advantages in order to maintain its combat edge.

Technological advances are likely to render inhabited aircraft extremely vulnerable. Advances in beyond visual range and stand-off weapons are making "dog-fight" tactics between combat aircraft obsolete. It will be necessary to carefully consider what the unique advantages of inhabited combat aircraft are that would justify the acceptance of such high levels of vulnerability, given their relatively high acquisition and maintenance costs.

In arriving at a solution for a new aerospace combat capability, the tasks that Australia's forces are likely to be undertaking by 2010 and beyond need to be carefully assessed. On the basis of such assessment, it will then be necessary to establish where and how Australia might need to apply its air combat power, and under what circumstances. The overall contribution towards national goals that is expected from air power needs to be thoroughly elucidated.

In addressing such issues, it will be necessary to utilise so-called "Concepts of Use" rather than basing an analysis on specific detailed scenarios, whose relevance can always be called into question. A scenario-independent approach is likely to be more readily defensible than an analysis that is based on a few specific scenarios. The range of tasks that might need to be considered might include non-traditional, but increasingly frequent, tasks such as urban warfare, terrorist attack and jungle guerilla warfare, as well as other "operations other than war" (OOTW).

The context that will govern the formulation of these Concepts of Use is given in section 3.

2.1 Need

The programmed withdrawal date (PWD) for the F/A-18 is 2012-2015, and 2015-2020 for the F-111. However, the shortening life-cycle of modern technologies indicates that these aircraft, even with their present upgrade programs, may not sustain capabilities sufficient for Australia's defence requirements beyond the next ten years. While the Asian economic downturn has tended to slow the rate of regional modernisation, indications are that Australia must maintain a vigilant overview of regional developments in examining its options for the transition to a future capability. In addition to meeting transitional requirements, any future capability must also be able to adequately satisfy requirements for 2020 and beyond.

A Current Force Capability Analysis is presently being conducted to inform the Defence Capabilities Committee (DCC) of the prospects for the current force and of whether what is presently being spent represents value for money. Some reuse of results obtained for the Air 5418 project (Follow On Stand-Off Weapon Capability) is being made. The analysis seeks to establish more precisely the draw-down dates for the F/A-18s and the F-111s. In particular, it will identify any factors that could cause the aircraft to fail to reach their currently proposed draw-down dates. Options that might need to be considered, if this were shown to be the case, include varying the rates of effort of the aircraft concerned and changing their flight regimes. Phase 2 of the Hornet Upgrade Project is planned to commence in 2006. There is some consideration being given to whether this should be curtailed. Concerns exist surrounding the availability of parts for the F/A-18s and F-111s. In addition, there is presently insufficient information available on the safe structural life of the F-111s.

The 2000 Defence White Paper will consider Australia's air dominance and strike capabilities. However the feeling is that it is unlikely that this white paper will provide specific guidance for the AIR 6000 project.

2.2 Affordability

The AIR 6000 project will face heavy competition for scarce resources, despite replacing a current "core" ADF capability. Budget issues that may impact on it are an existing capability backlog and ongoing funding concerns surrounding Australia's East Timor commitment. Defence has suffered a 2.3% real budget cut since the end of the cold war. Unfortunately, the Defence Reform Program (DRP) has failed to achieve the anticipated savings. New technologies, roles and requirements are constantly arising. As a result of a recent shift in government policy, there will need to be a shedding of some central ADF capabilities and roles, with consequent ramifications for strategic policy. Hard decisions will need to be made concerning which capabilities will be retained. Fixed guarantees on budget funding are unlikely. Performance requirements must therefore be linked directly to strategic policy. Costs must be held in check. Any enabling capabilities that are required must be integrated into the project from the outset, as additional funds are unlikely to be made available afterwards.

The rationalisation of aircraft supplier companies has reduced the level of competition and the number of designs being marketed. The available aircraft have limited range and high cost. On the other hand, new capabilities that offer alternatives to aircraft are in an immature state. Currently it is mooted that the AIR 6000 project will need to seek funding of $10bn or more. There is, however, likely to be considerable public scrutiny of this expensive defence project. An acquisition decision is currently scheduled for 2005 owing to the long lead-time needed for acquisition of the complex, sophisticated equipment involved. This long lead-time could diminish the effectiveness of the solution that is eventually provided, given the rapid rate of technological advances. "Smart procurement" methods, such as those mentioned in section 2.7, reduce this lead time by delaying a decision to the last possible moment. Nonetheless, there are limits beyond which the lead-time cannot be reduced.

An alternative strategy would be one of progressive acquisition rather than block acquisition of new systems. Progressive acquisition also provides a better ability to adapt to changing situations and enables better exploitation of evolving technologies. Progressive acquisition may, however, increase the unit cost. In measuring the affordability of candidate systems, it is necessary to come to some agreement on how the unit price of aircraft is defined. The cost of ownership is not just the number purchased multiplied by average fly-away cost. Spares, training, support and project management costs also need to be incorporated.

2.3 The Nature of Air Power

The need to consider systems aspects as well as equipment and personnel when acquiring new military capabilities is being increasingly recognised. These aspects include doctrine, concepts of operations, training, tactics, proficiency, leadership, adaptability and practical experience. They need to be included in any thorough analysis of an aerospace capability.

Battlespace information and intelligence are of particular interest as air power on its own is of no value unless it can be applied in a purposeful, directed manner. Information about the enemy and the disposition of their assets is essential in order to be able to achieve this. The information must be timely, accurate, reliable and sufficiently comprehensive to meet the commander's needs. Clearly, therefore, there needs to be interaction with related studies concerned with the ADF C4ISREW infrastructure whose purpose it is to meet such information requirements.

It is also important to recognise that air operations will normally be conducted in the context of joint or combined operations.

The recent emphasis of military operations for Australia appears to have shifted towards peace keeping and peace enforcing. Also, a new war-fighting paradigm has arisen among Western nations in recent times. In this paradigm, the priorities are to minimise risk to aircrew, minimise collateral damage, and to inflict an escalating scale of damage on a recalcitrant adversary. The latter requirement for escalating levels of destruction is a politically driven one, rather than being based on military principles. Cruise missiles, stealthy strike aircraft and precision guided munitions have been used to permit this paradigm to be realised. The use of precision technology of this kind needs to be combined with enhanced operational and maintenance skills in order to achieve high overall effectiveness.

Some possible solutions that need to be considered include missile systems, UCAVs, space-based, land-based and maritime systems. The emerging technologies have great promise, but there is an issue as to whether this promise can be delivered at a reasonable cost and in the required timeframe. Existing platform types, as opposed to exotic alternatives, have lower risk and possible acquisition and support savings.

Currently technology is being driven by the commercial environment rather than by military requirements, as was the case in earlier years. Therefore, there needs to be a greater emphasis on COTS technology, where it is available.

There are a number of questions that need to be investigated concerning the relative sophistication of weapons and platforms. More sophisticated, longer-range weapons permit cheaper, less sophisticated and less stealthy platforms to be used with consequent platform purchase cost and supportability savings. A problem with this approach is that such long-range and relatively autonomous weapons may be less discriminate in their effects. Another spectrum of choice concerns whether inhabited or uninhabited platforms are chosen. Uninhabited platforms raise issues concerning accountability and autonomy of action. Also, there are suggestions that uninhabited vehicles may require substantially more on the ground support and, in addition, lack the flexibility provided by having a human directly "in the loop". The cost effectiveness of these alternatives is another issue that must be considered. Finally, the required technological developments for the more radical options may be a long time in reaching fruition, which is a risk that would need to be borne if one of these were selected.

In acquiring a future force, affordability of the capability sought needs to be carefully considered. This will involve estimating the total cost of ownership and the likely levels of funding available.

As has been suggested elsewhere, potential adversaries may come to have access to the same or similar technology as Australia, together with comparable competence in its use. In order to be able to defeat such adversaries, Australia must also be able to adapt the available technology, and to innovate in its application, to achieve the greatest possible effect under Australia's unique circumstances.

2.4 Technological Advances

Advances in a number of technology areas will have a profound affect on the project. Some important aspects of technology are discussed below.

2.4.1 Sensors

There is a strong trend towards the integration of EW and radar systems. This allows more precise location and identification of targets and enhanced self-protection. Another trend is for attacking aircraft not to radiate. Instead, remote illuminators are used. Electronic scanning is replacing mechanical scanning in radar systems, with conformal arrays giving the possibility of all round coverage. Furthermore, low-duty-cycle radars are being developed which rely on emitting very few pulses. Stealth designs minimise the signature. Long wave radar may however be a threat to stealth aircraft in future. More use is being made of passive sensors including infrared search and track (IRST) systems. Data links are also coming to rely on low probability of intercept transmissions. These LPI systems are, however, very expensive. In addition, they need to be supported by appropriate operational doctrine such as reduced use of afterburners, communications transmissions and active sensors. Also, flight path and altitude must be chosen to minimise the chance of detection. The life-cycle for a radar is about a quarter of that of a platform. Therefore radar developments could rapidly overtake and defeat the stealth features of platforms.

A sensor-related issue is that of beyond visual range engagement capability. Such a capability is of interest because there is now a high probability of an aircraft being destroyed if fired on within visual range. The Rules of Engagement of Australia's opponents may be less restrictive than those currently applied by Australia.

2.4.2 Weapons

The lethality and resistance to countermeasures of weapons is rapidly increasing. There is a benefit in using long range weapons, in that longer range means that the launch platform is less vulnerable to attack. Thus stealth features may be redundant if long-range missiles are employed. The range of rocket ram-jet propulsion missiles would enable them to be launched from outside the detection range of fifth generation aircraft. Future developments may result in missiles that have greater than Mach 5 speed, operate in all weathers and are difficult to avoid or counter.

Significant improvements in aircraft and weapons technology are expected by the year 2020 as many proposed technological advances could be mature by that time. Australia's war-fighting edge lies in the technical and tactical areas, in concert with its unique strategic situation. As with other technology, Australia needs the ability to be able to optimise weapons for its own specific purposes and circumstances. This will demand a close association between DSTO, the ADF and manufacturers. A recent example of such cooperation is the ASRAAM agreement with BAE Systems.

2.4.3 Stealth

Very Low Observability (VLO) design techniques for aircraft were established in the early 1980s and have been used in aircraft for air superiority, strike and reconnaissance. The US has made a major commitment to the R&D and infrastructure required for this technology. So far, only the US has made the massive investment necessary for VLO. VLO allows deep penetration of hostile air space with high probability of mission success and high survivability. Its combat advantages come from the ability to shoot with impunity and to maintain an assured first shot. The technology also provides covertness.

Low Observability (LO) and VLO are discontinuous ranges of the observability spectrum. In the case of LO, the observability characteristics have secondary priority and the results obtained are limited. They mainly provide improved end-game ECM effectiveness.

In VLO designs, by contrast, observability characteristics have equal or higher priority than other design considerations. The results that may then be obtained are unconstrained and dramatic. They achieve survivability with or without ECM.

On the other hand, LO characteristics are frequently introduced as the result of retrofit, depot or block changes. In the case of new aircraft development it is usually limited to frontal RCS at the higher radar frequencies (typically used in close combat and by anti-aircraft missiles). Infrared radiation signature reduction may also be included. Such designs can provide a first shot opportunity. They also improve the effectiveness of electronic protection (EP).

Stealth greatly reduces the detection ranges of adversary sensors. Stand-off jamming also has a similar effect as far as radar detection is concerned and can be used in conjunction with stealth to achieve an increased effect. Towed and air launched decoys, on the other hand, may be employed to yield an enhanced end-game survivability for the aircraft.

Depending on configuration and design options, significantly different levels of reduction may be achieved. Many current aircraft types have undergone LO experimentation. The effectiveness of LO reduction depends on how early in the design cycle it is introduced. LO measures can impact the weight, drag, propulsion efficiency and perhaps also the avionics performance of aircraft. The RCS of weapons can ruin the effectiveness of a low observable design. This can be countered by carrying weapons internally.

2.4.4 Information Systems

A striking difference between fourth and sixth generation aircraft is the greatly increased reliance on information technology and information processing systems. For example, the F22 aircraft has the equivalent of two supercomputers on board. The balance of superiority is moving away from platforms and into weapons and information exploitation. Information gathering and networking allow weapons power to be focussed on the intended target. However, this technology is currently extremely costly.

Information, intelligence, target identification are the force effectiveness multipliers which permit highly focussed and effective attack. Other important factors are situational awareness, range, weapons numbers and agility, as is the ability to deal with threats at a distance. Situational awareness entails better information, not simply more information. There is a need for fused, distilled, relevant and timely information.

There will be an increasing emphasis on the exploitation of information, which needs to be tailored to, and focussed on the tactical situation.

Australia currently has very limited capabilities for integrating information from systems. This matter is currently being addressed in other work such as the C4ISREW Study [6]. This Study will also address issues that are of relevance to AIR 6000. One such issue is the extent to which cooperative engagement capabilities will feature in a new capability.

2.5 Innovative Solutions

In addition to traditional combat aircraft, some innovative solutions to the problems of air dominance and strike capability have been proposed.

2.5.1 Uninhabited Air Vehicles

The use of Uninhabited Air Vehicles (UAVs) and Uninhabited Combat Air Vehicles (UCAVs) is becoming an increasingly attractive option. This is because the rapid advance of information technology means that a high degree of machine intelligence can be accommodated within the volume, weight and power limitations imposed by an airborne platform. Removing the pilot lifts restrictions on manoeuvrability due to human physiological constraints. Also, life support equipment is rendered superfluous. Perhaps the most significant feature of such vehicles is that the lack of a human pilot means that there is no "CNN factor" should one be shot down. The major distinction between a UCAV and a cruise missile is that a UCAV is reusable in nature.

Uninhabited Air Vehicles are currently being used for long duration, surveillance, target identification and designation. The demonstration of UCAV use for suppression of enemy air defences (SEAD) is likely to occur by 2003, with operational SEAD and strategic strike achieved by around 2015. The use of UCAVs for SEAD missions is particularly attractive because of the relatively high risk associated with such operations. Robotic wingmen in support of inhabited aircraft could be in use during the decade 2020-30. In this setting, UCAVs would be used for such tasks as carrying radar and weapons, to reduce the risk to which the human pilot or crew was exposed.

2.5.2 Air Launched Cruise Missile (ALCM)

The concept of this proposed solution has been developed as part of the UK's future offensive air system (FOAS). The innovative feature here is the use of a relatively low cost platform to enable the weapons to be employed in a wide range of possible conflict areas. In one option, a modified commercial airliner would be used as the platform. A number of cruise missiles would be carried within the body of the aircraft and launched through penetrations in the rear pressure bulkhead. The aircraft would operate at a safe stand-off distance.

Alternatively, a military airlifter could be employed as the ALCM platform. This would have the advantage of not requiring any aircraft modification, since the missiles would be able to be deployed through the rear cargo door.

A relatively small number of such aircraft could be used to generate a high intensity of operations at a significant radius from their base.

While a technically feasible possibility, land launched cruise missiles would not appear to be an option currently under consideration. Their restricted range would mean that they would only be useful against potential targets in the immediate region. They would also seem to be diplomatically undesirable, since they would be unambiguously directed towards certain nations.

The Missile Technology Control Regime places severe restrictions on the export of rocket systems and uninhabited air vehicle systems, including cruise missiles, which are capable of delivering a payload of 500 kg or more to a range of 300 km or more.

2.6 Regional Considerations

In developing a new aerospace combat capability, there is a need to take account of current and projected regional capabilities. These may include American, European and Russian products and cover AEW&C, UAV, surveillance satellites and EW systems. For example the PRC is acquiring a large fleet of Su-27/30Ks, and India and Malaysia have acquired late model MiG-29s. Reports are that India will also obtain Su-27/30s. There are also late model F/A-18s and a small number of F-16s in the region.

Continued and improved monitoring of regional capabilities, and forecasting of likely regional acquisitions out to 20 years or beyond, needs to be undertaken. In examining these capabilities it is important that a range of factors be included. It is insufficient to merely focus on inventories of military equipment. Instead, a holistic approach must be adopted.

There is concern about the proliferation of missiles in the region. These may affect solutions involving ballistic missiles, space-based systems and cruise-missiles.

2.7 Procurement Practices

Throughout the Western world, there is an increasing emphasis on "smart procurement". This is aimed at achieving a cost-effective result through concentrating on processes that add value and minimising bureaucratic overheads in defence acquisition procedures. The UK adopted such an approach following the 1997 Strategic Defence Review, which identified systemic failings in the previously existing methods. DAO is now following a similar approach, based on the PRINCE2 project management methodology. A heavy reliance is placed on Integrated Product Teams (IPTs) which enable customers, procurers, manufacturers and designers to work closely together. There is a move away from traditional "cost plus" contracts towards a "cost share" approach. There is also increased willingness to spend money on risk reduction efforts. The new procurement model has just two decision points, so called "gates". The initial gate occurs at the end of the concept phase, prior to the assessment phase. The main gate occurs prior to the demonstration phase.

Performance has traditionally been the driver for defence projects. In the modern era, technology is abundant and selection between available alternatives is difficult. In making selections, trade-offs must be considered and compromises made. Innovation remains important and should be promoted and fostered.

Technology demonstration programs are used to reduce risk. Excessive competition between companies is curtailed, to avoid wasteful utilisation of scarce resources.

International collaboration allows nations to contribute their national expertise and to take from a common pool of knowledge those aspects that meet their independent needs. This approach is presently being adopted in Europe. Such international cooperation needs to be conducted on the basis of industry best practice, not on one of politically driven work-sharing, an approach that has proven to be unsuccessful in the past.

2.8 Supportability

The introduction of advanced predictive diagnostic maintenance aids permits a reduced level of scheduled maintenance. The trend is towards a two-level maintenance philosophy for avionics systems. Circuit cards will be replaced rather than boxes. Concerns presently surround how repairable composite materials may prove to be in the field, and how maintainable the stealth characteristics of sophisticated aircraft may be.

Aircraft need be designed for rapid turn-around on the ground for high sortie generation rates to be achieved. This is important because high sortie generation rates could allow current aircraft to be replaced by fewer advanced aircraft. Avionics systems based on COTS and open systems architectures may also enhance supportability and reduce cost.

Design features that enhance supportability include provision for growth capacity in mission systems, easy accessibility to maintenance panels and components, and on board automatic diagnostic equipment. The use of FADECs tends to enhance engine reliability. Modern designs strive for a reduced logistic footprint to permit more rapid and convenient power projection.

Some strategists are strongly convinced that Australia needs the ability to develop and integrate new systems. To be able to support and tailor whatever systems are acquired, access to computer system source code is needed.

Historically, Australian industry has had substantial involvement in fighter aircraft projects. This should continue to be encouraged in future. However, the large additional overheads that the Australian government was prepared to bear in order to support Australian industry involvement in the F/A-18 project are highly unlikely to be repeated for future acquisitions. The question therefore is how Australian industry involvement can best be promoted. Some form of government intervention might be required to achieve the desired outcome.

2.9 Assessment Methodologies

A number of DSTO researchers have been providing input to several DSTO AIR 6000 working groups. Most attention so far has been devoted to individual analysis techniques. The intention is to include those that appear to be most useful into a more comprehensive assessment process which, however, has not yet been fully articulated. A sample scenario for assessing the suitability of various analysis techniques has been established. Unfortunately, this scenario does not appear to be designed to emphasise joint system aspects. Several analysis methods have been suggested so far. These suggestions have arisen primarily from meetings of the operational analysis and systems working groups.

Firstly, the possibility of using existing campaign planning tools has been considered. One such tool is THUNDER. This is a large air campaign model. THUNDER was originally designed for analysing large-scale cold-war scenarios. It may, however, be difficult and risky to adapt it to scenarios of relevance to Australia. Also, because it is based on detailed simulation, it is questionable how the results could be summarised in way that could provide useful guidance for AIR 6000. Similar objections are likely to apply to other existing campaign planning tools.

Another analysis approach that has been suggested is RAND's Exploratory Analysis methodology. Dick Body of MOD has proposed that a variant of exploratory analysis be applied to AIR 6000. His variant has been given the name CASEAT. This method has evidently been selected by AOD for further AIR 6000 operational analysis.

One problem with the Exploratory Analysis approach is that a single number is calculated as a measure of effectiveness. Examples are "penetration distance" or "surviving reinforcement force". However, a single such number is rarely sufficient to adequately characterise a capability. Therefore, there needs to be some means for agreeing on a range of measures and of combining the results for these in a way that can be used as a basis for making joint systems recommendations.

Another problem with the exploratory analysis approach is that it is based on mean value analysis. This is inadequate to properly represent the effects of information, and it is these effects that lie at the core of the joint systems aspects of the project.

Richard Hodge of SPD has suggested his Force Option Analysis approach. This is based on a systems engineering methodology and identifies the important functions required for various situations. Also, Alan Burgess of LOD has suggested an analysis approach that looks at problem definition and identifies critical issues and values, on the basis of seminars, wargames, simulation and modelling.

Another method for addressing joint systems issues might be based on the USAF Joint Mission Framework. This relates joint tasks to the operational context, and identifies process categories and value streams. Jennie Clothier has advocated such an approach.

However, none of the individual approaches listed above seems to be entirely satisfactory for treating all of the joint systems aspects of the AIR 6000 project. To remedy this deficiency, a "theory of joint systems" is proposed by the author. This theory encompasses both analytical techniques similar to those of exploratory analysis, architectural techniques such as a Joint Mission Framework, and experimental methods such as those suggested by Alan Burgess. This collection of techniques is organised into a coherent process for treating the joint systems aspects of the project by using soft operations research concepts in the form of Checkland's Soft Systems Methodology [7, 8, 9].

The analytical techniques that are proposed for joint systems work are based on calculating probability distributions instead of mean value analysis [10, 11]. Hence, they are capable of directly including the effects of operational information and uncertainties that are central to joint systems issues. The techniques proposed would be similar to those described by Rod Staker elsewhere [12].

3. Context for the Work

3.1 Strategic Outlook

Since the publication of Defence of Australia in 1987 (DOA 87), Australia's published strategic policy has evolved significantly. From focussing solely on the development of capabilities to Defeat Attacks on Australia (DAA), the most recently published strategic policy (ASP 97) recognises potential military roles for the ADF spanning a spectrum of conflict in scale, intensity and geographic location.

Although defeating attacks against Australia's territory remains the core force structure priority (and is the pre-eminent criterion for capability development); investment decisions may be influenced by the ability of Australia's military forces to also contribute to the task of Defending Regional Interests (DRI).[1] Flexibility, adaptability and interoperability have thus become important considerations in the development of appropriate ADF capabilities.

Despite significant changes in strategic policy there have been some enduring tenets to our strategic outlook.

3.1.1 Regional focus

A regional focus is an enduring theme in Australian strategic outlook. For example the pursuit of a 'knowledge edge' embraces the revolution in military affairs (RMA) that is occurring but recognises that, whereas the US seeks this advantage against any adversary anywhere in the world, Australia's scope is limited to its immediate strategic environment. Prevailing political, strategic, societal and economic circumstances (and limits to defence spending) are likely to reinforce this regional focus.

3.1.2 Self-reliance in Defence

The concept of self-reliance in defence has been a central feature of our strategic policy since the 1976 Defence White Paper. It means that Australia must be able to defend its territory without relying on the combat forces of other countries. Here the distinction is drawn between self-sufficiency, where all military capabilities would need to be fully supported from within Australia, and the concept of self-reliance where Australia can undertake independent military action with capabilities that may be sourced from overseas but supported through local industry involvement and a network of allies. Suitable Australian Industry involvement in defence has thus become a major part of the Government's Defence policy. This is likely to continue.

[1] It is recognised that the capabilities developed to meet these higher-priority tasks will provide the Government with a range of options to contribute to military operations supporting our Global Interests (SGI).

3.1.3 Defence in depth

The sea-air gap (SAG) to our north provides a natural impediment to an adversary attacking the Australian mainland. The employment of a range of capabilities within and across the sea, air and land environments would further complicate the planning and conduct of attacks on Australia. Development of suitable complementary capabilities is important in implementing this concept of defence in depth. The challenge is to integrate the individual capabilities acquired into a system of systems with the emergent properties needed.

3.1.4 Joint operations

The concept of joint operations involving components of sea, air and land forces is well established and is a key consideration in defence capability development. Joint operations form the cornerstone of ADF force structure and doctrine. This is unlikely to change.

3.1.5 Coalition operations

Historically Australia has undertaken many military operations as part of a coalition. The importance of our relationships with our long-standing allies is formally recognised in our Defence policy. Coalition operations with allies may thus be regarded as an enduring key planning assumption for our strategic outlook.

3.2 Military conflicts

3.2.1 Spectrum of operations

The ADF may be called upon to undertake both operational and non-operational roles associated with the application of military power across a wide spectrum of conflict. An indication of the range of potential operations is given in Figure 1.

PEACE	OOTW	WAR
Emergency relief	Peace enforcement	
Support to civil authorities	Peacekeeping	Local conflicts
Counter-terrorism	Sanctions	Regional wars
Evacuation	Humanitarian aid	General war

Although the ADF may, and has, been called upon to supplement the civil emergency services in times of exceptional demand, it does not normally provide these services to the civil community. There are two standing exceptions to this principle. The first is the provision of specialist support to counter-terrorist operations. The second is support to customs, immigration, fisheries and other civil authorities by providing surveillance and response forces in Australia's coastal waters.

In peacetime the ADF may also be called upon to conduct an evacuation of Australian nationals from a volatile situation overseas when Australian interests are engaged.

In recent years Australian governments have often faced decisions about deployment of elements of the ADF to undertake humanitarian operations overseas. These are usually in response to United Nations initiatives and reflect Australia's role as a responsible international player. Australian forces may also be called upon to undertake a range of peacekeeping and peace enforcement operations. Being overseas conflicts, where Australia is not one of the protagonists, these are classed as operations other than war (OOTW). Involvement is usually in response to United Nations initiatives.

War could range from low-intensity conflicts through to a general war with wide geographic extent and involving many nations.

3.2.2 Scenarios

Detailed scenarios may be developed for studying the application of air power in specific circumstances. Current, or past, situations can be modelled in depth. Broad analyses of options can be undertaken using the basic tasks the ADF may be called upon to do (*i.e.* Defeating attacks against Australia, defending our regional interests and supporting Australia's global interests).

Strategic guidance, however, evolves and the lead times for introduction of new or enhanced capabilities are usually long. Forecasts of strategic outlook may provide broad indications of potential situations where the ADF may be called upon to act. Such forecasts, however, contain considerable uncertainties that increase as we extend the time horizon of the forecast.

By choosing missions of interest that we expect to be undertaken in conflicts now and in the future, some progress can be made in assessing what ADF capabilities should be sought in the future. (For example, neutralising an enemy's air defence system or the hunting of enemy high-value mobile targets.) These general cases can provide a means of testing capability options for specific applications of air power.

3.2.3 The enemy as a system

Although specific enemy equipment or installations may be prosecuted as targets, the overall aim in a military conflict would be to remove or negate the enemy's ability or willingness to undertake military activities against Australia. It is thus important to maintain a holistic perspective of the enemy as a total entity where their ability to undertake military operations against Australia is an emergent property of their total military system, supported by their national infrastructure and economy and backed by societal and political directives.

Aspects of the enemy as a system may be broadly placed into one of the five following categories [2].

1. Enemy command and leadership. This could include both military and political leaders and support to their decision-making and command processes.
2. Support systems. Power, command and communications networks, civilian telecommunications and information technology systems may all be included in this category.
3. Key infrastructure. Included here are transport networks, distribution and supply centres and key industrial installations or complexes.
4. Popular will. The media, influential people and political pressure or power groups all influence a nation's will to be at war.
5. Fielded military forces. These include equipment, personnel, organisation and doctrine.

3.3 Air Power Doctrine

Australia's application of air power is described in several publications, covering doctrine at the strategic, operational and tactical levels of war [1, 2, 3].

Strategic-level doctrine establishes the fundamental principles for the ADF for employment of air power in pursuit of national objectives [1, p.4].

Operational-level doctrine is concerned with the planning and conduct of campaigns [2].

Tactical-level air power doctrine provides the procedural basis for detailed mission planning and execution of air tasks [3].

3.4 Core Air Power Capabilities

3.4.1 Control of the air

An effective control of the air capability is essential if ADF assets are to operate unhampered by the threat of hostile air attack. The degrees of control of the air are broadly classified as [1, 2]:

- **Local air superiority** (or favourable air situation) results when control of the air is applied for a limited period of time and over a given area. The aim is to ensure that enemy air power does not pose a serious threat to one's own population, national infrastructure or international lines of communication, or to one's own air, land or sea operations.
- **Air superiority** is achieved when control of the air dominates enemy air power to the extent that one's own air, land and sea operations can be undertaken at specific times and locations without interference by enemy air forces.

- **Air supremacy** applies when enemy air power does not present a threat to national interests, or one's own air, land and sea operations.

Control of the air is considered as comprising two components [1, 2]:

1. *Offensive counter-air (OCA)* focuses on the neutralisation of the enemy's air power to ensure control of the air for one's own air forces. Targets for OCA may include enemy air defence systems, aircraft in the air or on the ground, air and ground crews, command and control systems, air bases and supply and storage areas.
2. *Defensive counter-air (DCA)* actions aim to deny an enemy control of the air by nullifying or reducing the effectiveness of their hostile air action.

3.4.2 Precision strike

Precision strike is the ability to use air power to destroy or neutralise targets and to undermine the enemy's will to fight through the application of firepower with a high degree of lethality, discrimination and accuracy.

3.4.3 Precision engagement

Precision engagement is the ability to locate and engage enemy elements directly without applying firepower. It may be used as a precursor to control of the air or precision strike operations.

3.4.4 Rapid force projection

Rapid force projection is the deployment of air power to locations in or near an area where the Government wishes to exert strategic influence on the basis of force. In particular deployment to bases in northern Australia that form an arc of operating locations across Australia's northern approaches.

3.4.5 Information exploitation

This involves the use of aerospace power to provide knowledge required for the conduct of successful air, land and sea operations. The aim is to derive the greatest possible knowledge about the enemy and any neutral forces while keeping similar knowledge of one's own forces from the enemy.

An information exploitation capability encompasses:

- using aerospace power to gather data from airborne surveillance and reconnaissance systems;
- translating that data into information;
- fusing that information with information available from other sources;
- collating, analysing, storing and communicating salient information to the relevant commanders, their staff and combatants.

- Using the knowledge derived from the information effectively and quickly to determine appropriate responses and optimise any subsequent military operations.

4. Conclusion

The AIR 6000 project seeks to provide Australia with a highly effective, future air combat capability at an affordable price. Furthermore, the effectiveness of the capability needs to be guaranteed in the face of the many future uncertainties for Australia, its region, and in international affairs. This paper has detailed some assumptions concerning Australia's strategic outlook that will be used to circumscribe these uncertainties in future Joint Systems Branch work related to the project, in order to enable sensible conclusions to be reached.

A particular source of uncertainty is the rapid pace of technological development. New and emerging technologies, particularly those related to information processing and handling, need to be judiciously exploited to ensure that enhanced effectiveness is achieved, at reduced cost, under Australian circumstances.

Due consideration of the relevant joint systems aspects will be essential if Australia is to acquire an effective new capability, rather than merely new technological marvels to flaunt.

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Appendix A: Glossary

ADF	Australian Defence Force
AEW&C	Airborne Early Warning and Control
AOD	Air Operations Division
AMRL	Aeronautical and Maritime Research Laboratory
ASRAAM	Advanced Short Range Air to Air Missile
BaeA	British Aerospace, Australia
bn	1,000,000,000
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
DAA	Defeating Attacks on Australia
DCC	Defence Capability Committee
DCA	Defensive Counter Air
DRI	Defending Regional Interests
DRP	Defence Reform Program
DSTO	Defence Science and Technology Organisation
EP	Electronic Protection
ESRL	Electronics and Surveillance Research Laboratory
EW	Electronic Warfare
FADEC	Full Authority Digital Engine Control
FOAS	Future Offensive Air System
GPS	Global Positioning System
CEP	Circular Error Probable
IRST	Infrared Search and Track
JSB	Joint Systems Branch
LGB	Laser Guided Bomb
LPI	Low Probability of Intercept
OCA	Offensive Counter Air
OOTW	Operations Other Than War
PGM	Precision Guided Munition
PRC	People's Republic of China
PWD	Planned Withdrawal Date
RAAF	Royal Australian Air Force
EO	Electro-Optic
EW	Electronic Warfare
RF	Radio Frequency
RMA	Revolution in Military Affairs
SAG	Sea-Air Gap
SAM	Surface to Air Missile
SAR	Synthetic Aperture Radar
SEAD	Suppression of Enemy Air Defence
SGI	Supporting Global Interests

SLMP	Structural Life Management Plan
SOW	Stand-Off Weapon
SSM	Soft Systems Methodology
UAV	Uninhabited Aerial Vehicle
UCAV	Uninhabited Combat Aerial Vehicle
UK	United Kingdom

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Rod Staker and Terry Moon

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DGSTA Defence Intelligence Organisation
Manager, Information Centre, Defence Intelligence Organisation

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